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TRANSITION TO THE NEW GENERATION OF DATA COMMUNICATION INTERFAC--ETC(U)

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NATIONAL COMMUNICATIONS SYSTEM

TECHNICAL INFORMATION BULLETIN
76-1

TRANSITION
TO
THE NEW GENERATION
OF
DATA COMMUNICATION INTERFACE STANDARDS

SEPTEMBER 1976

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This NCS Technical Information Bulletin (TIB) describes the purpose and interrelationships of an evolving family of new Federal standards for interfacing users's data terminal (or data processing) equipment with telecommunication systems. Each of the new standards, including their provision for transition is also described. Additionally, the commonality of features of specific interfaces are identified which will facilitate design of universal data terminal equipment to meet the spectrum of user applications. The path is clearly shown from where we are today to where we want to gracefullly evolve.

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NCS TECHNICAL INFORMATION BULLETIN 76-1

TRANSITION TO THE NEW GENERATION OF DATA COMMUNICATION INTERFACE STANDARDS

September 1976

PREPARED BY:

HAROLD C. FOLTS
Senior Electronics Engineer
Office of NCS Technology
and Standards

APPROVED FOR PUBLICATION:

Marshall L. Cain

MARSHALL L. CAIN
Assistant Manager
Office of NCS Technology
and Standards

FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program which is an element of the overall GSA Federal Standardization Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee, identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the Electronic Industries Association, the American National Standards Institute, the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents an overview of how these joint efforts are contributing to the development of compatible Federal, national, and international standards in the area of data communication interface standards. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs, or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

Office of the Manager
National Communications System
ATTN: NCS-TS
Washington, D.C. 20305

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I
INTRODUCTION

This NCS Technical Information Bulletin (TIB) describes the purpose and interrelationships of an evolving family of new Federal Standards for interfacing users' data terminal (or data processing) equipment with telecommunication systems. These new standards cover what is defined later in Section III as "Level 1" of a hierarchy of data communication protocols. There are two types of general purpose electrical characteristics plus three specific interfaces where the functional, mechanical, and procedural characteristics for particular applications are defined.

Until recently, there have been no formal Federal Standards for data communication interfaces. As a result, the Electronic Industries Association (EIA) standard RS-232C has been widely implemented de facto by Federal departments and agencies except where the MIL-STD-188 series applied at departmental levels. RS-232( ) has well served a useful need as the pervasive interface standard for over 15 years, but today's requirements and technology demand higher performance and greater flexibility to meet the expanding variety of user applications.

Close liaison is being maintained between the various U.S. industrial standards activities and the Federal Government, as well as with the associated international bodies to produce standards that are universally compatible. Diverse inputs from a wide spectrum of interests, including users, manufacturers, and communication carriers, are producing a new generation of standards which will economically and effectively meet the advancing needs of the user community.

The number of standards included in the new generation may at first appear like a proliferation. On the contrary, they are a carefully planned set of closely interrelated standards tailored for today's rapidly advancing technology. Of particular significance is the provision for transition from the large inventory of existing RS-232C equipment to the new generation without forcing obsolescence or costly retrofits.

Each of the new standards, including their provision for transition is described in this TIB. Additionally, the commonality of features of specific interfaces are identified which will facilitate design of universal data terminal equipment to meet the spectrum of user applications. The path is clearly shown from where we are today to where we want to gracefully evolve for the new generation of data communication equipment interfaces tomorrow.

II
APPLICABLE FEDERAL STANDARDS

The following is a summary of the applicable Federal Standards showing their relationship to associated standards (Table 1) published by the Electronic Industries Association (EIA), American National Standards Institute (ANSI), International Organization for Standardization (ISO), and International Telegraph and Telephone Consultative Committee (CCITT):

1. FED-STD-1020, Telecommunications: Electrical Characteristics of Balanced Voltage Digital Interface Circuits, September 24, 1975.

This standard adopts EIA standard RS-422 for use by the Federal Government. A revision to this standard, FED-STD-1020A, is currently being prepared and coordinated to adopt the revised EIA standard, RS-422A. The revisions are minor in nature and do not change any parameter values.

This standard is essentially the same as CCITT Recommendations X.27 and V.11.

The MIL-STD-188-114 includes the same specification as FED-STD-1020 (RS-422) except the amount the generator offset voltage allowed is 0.4 volts instead of 3.0 volts. The restricted offset provides additional flexibility for transition from MIL-STD-188-100 and MIL-STD-188C to MIL-STD-188-114, particularly with relation to the change in signal sense.

2. FED-STD-1030, Telecommunications: Electrical Characteristics of Unbalanced Voltage Digital Interface Circuits, September 24, 1975

This standard adopts EIA standard RS-423 for use by the Federal Government. A revision to this standard, FED-STD-1030A, is currently being prepared and coordinated to adopt the revised EIA standard, RS-423A. The revisions are minor in nature and do not change any parameter values.

This standard is essentially the same as CCITT Recommendations X.26 and V.10.

The MIL-STD-188-114 includes the same specification as FED-STD-1030 (RS-423).

3. FED-STD-1031 (PROPOSED), Telecommunications: Transitional Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment for operation on Analog Telecommunication Networks.

This standard adopts EIA proposed RS-XYZ for use by the Federal Government. RS-XYZ is presently being coordinated in both the Federal Government and industry for comment prior to publication.

This standard is essentially compatible with the interchange circuit definitions of CCITT Recommendation V.24 and provides the same connector and pin assignment specification as proposed ISO International Standard 4902.

4. FED-STD-1029 (PROPOSED) Telecommunications: General Purpose Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment for Operation on Analog Telecommunication Networks.

This standard adopts EIA proposed standard RS-ABC for use by the Federal Government. RS-ABC is presently under development in EIA Technical Subcommittee TR30.2 with final draft expected by 4 January 1977.

This standard is essentially compatible with the interchange circuit definitions of CCITT Recommendation V.24 and provides the same connector and pin assignment specification as proposed ISO International Standard 4902.

5. FED-STD-1040 (PROPOSED) Telecommunications: General Purpose Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment for Synchronous Operation on Digital Telecommunication Networks.

This standard adopts the proposed American National Standard "ANSI X.21" for use by the Federal Government. "ANSI X.21" is presently being coordinated in both the Federal Government and industry for comment prior to publication.

This standard is a consolidation of the specifications of CCITT Recommendations X.21 and X.24, and proposed ISO International Standard 4903.

	ASSOCIATED STANDARDS				
FEDERAL STANDARD	MIL-STD	EIA	ANSI	CCITT	ISO
1020	188-114	RS-422		X.27,V.11	
1030	188-114	RS-423		X.26,V.10	
Proposed 1031		Proposed RS-XYZ		V.24,V.10	DP4902
Proposed 1029		Proposed RS-ABC		V.24, V.10,V.11	DP4902
Proposed 1040			Proposed "ANSI X.21"	X.21,X.24	DP4903
		RS-232C		V.24,V.28	DP2110

TABLE 1

Summary of Associated Standards

III
HIERARCHY OF INTERFACE LEVELS

Interfaces for data communications have traditionally been specified for operation between data terminal equipment (DTE) and data circuit-terminating equipment (DCE), formerly called data communications equipment. Figure 1 shows the basic block diagram of a typical interconnection. The DCE is generally considered part of the telecommunication network as far as the interface and DTE's are concerned.

A complete interface is defined by a number of characteristics. They include the electrical, physical, and functional characteristics as well as the necessary procedures to facilitate the transfer of data across the interface. There are a number of protocols that can be involved in different applications and modes of operation. Therefore, a hierarchy has been defined to clearly identify the levels of protocol so that they may be independently treated. These levels are described as follows:

Level 1 - Physical, electrical, functional, and procedural level used to establish, maintain, and disconnect the physical link between the DTE and the network or between DTE's.

Level 2 - The link control level for interchange of data between the DTE and the network or between DTE's.

Level 3 - The network control level which defines the formatting of messages or packets and the control procedures for transfer of user data through a packet or message switching network.

Higher levels - System control and user communication protocols for exchange of user data between operating systems.

It is essential that each level be defined and kept independent of each other level in order to achieve maximum flexibility in accommodating a variety of applications. Additionally, the evolution to improved techniques and future technology will be greatly facilitated because one level can be changed without interfering with other levels. An example of the hierarchy as applied to packet switching is shown in Figure 2.

The interface standards addressed by this TIB are for Level 1 application. These include the general purpose electrical characteristics and specific interfaces with the physical, functional, and procedural characteristics for different types of telecommunication networks and services. The other levels are being presently addressed either by active standards development efforts or are planned as topics for future study.

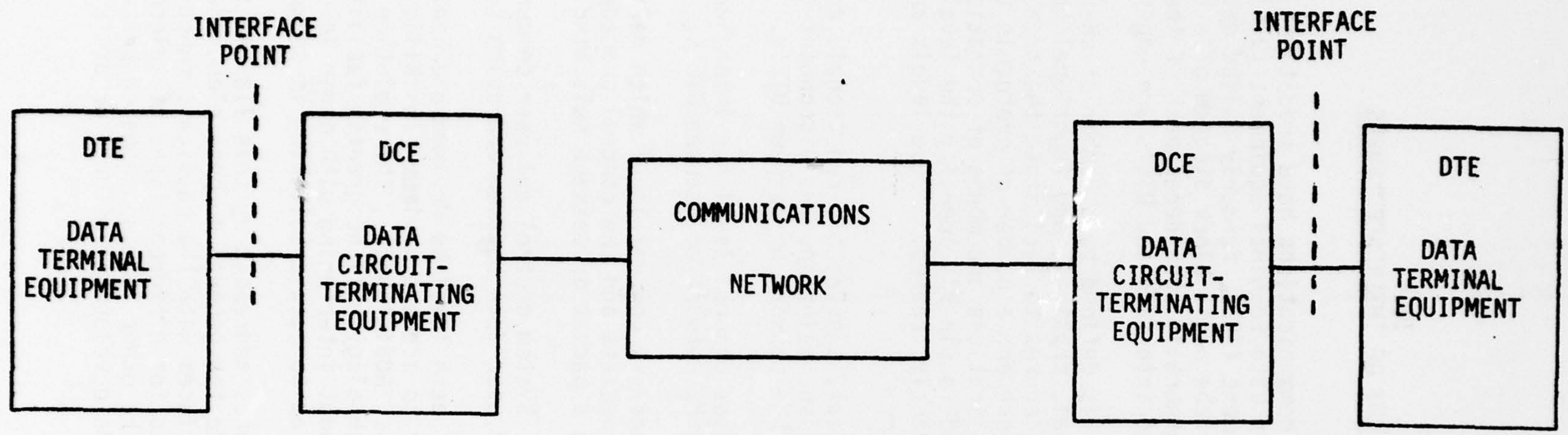

FIGURE 1

TYPICAL INTERCONNECTION

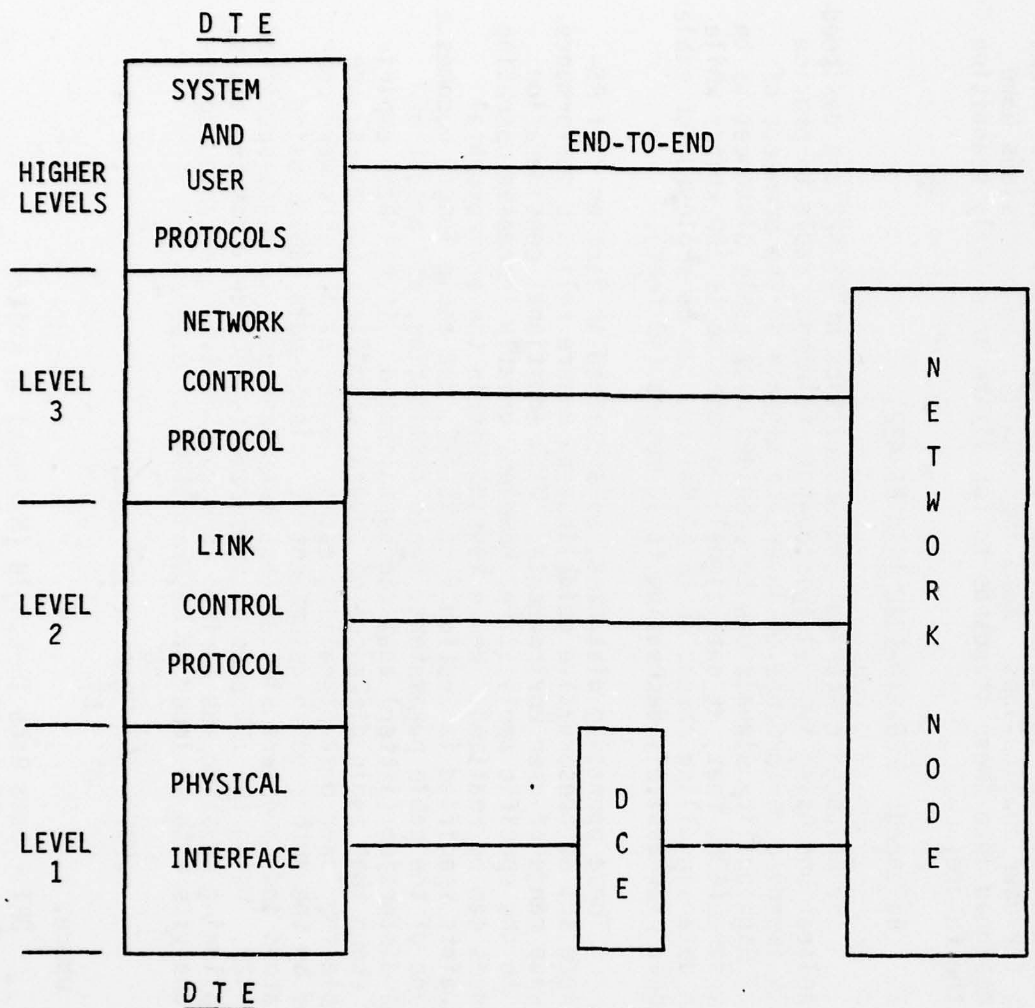

FIGURE 2

HIERARCHY OF INTERFACE LEVELS
FOR PACKET SWITCHED APPLICATIONS

IV
ELECTRICAL CHARACTERISTICS

The first in the new generation of interface standards to be completed and approved are the general-purpose electrical characteristics for digital interface circuits. They are FED-STD-1020 which adopts the EIA standard RS-422 for balanced circuits and FED-STD-1030 which adopts EIA Standard RS-423 for unbalanced circuits. The new standards were developed to meet the advancing state-of-the-art in integrated circuit technology and greatly enhance the performance of d.c. digital baseband signals across interfaces. It was necessary to develop two general-purpose standards, one for balanced and another for unbalanced electrical characteristics to provide a wide range of flexibility for user applications. More importantly, the provisions have been designed into these standards to facilitate an orderly transition into the future.

1. Balanced: FED-STD-1020 (EIA RS-422)

The balanced electrical characteristics of RS-422 are designed for applications using typical twisted-pair telephone cable to provide greatly improved performance of interface signals in the presence of noise. High quality signals can be provided over cable distances up to 1200 meters (4000 feet) at data signalling rates up to 100 kbit/s while higher data signalling rates, up to 10 Mbit/s, can be employed for cable distances progressively decreasing to 12 meters (40 feet).

These operating distances, as specified in Section 7 of RS-422, were set as conservative guidelines to ensure reliable performance in a wide range of user environments. With additional consideration given to the specific application, however, greatly increased operating distances can be realized. While keeping within the environmental constraints specified in Section 5 of RS-422, the cable length becomes a function of the cable parameters, cable termination, and amount of signal distortion (jitter) that can be tolerated. It has been empirically shown that cable distances of several kilometers (or miles) are possible for lower data signalling rates. A series of tests were conducted by the author on an assortment of twisted-pair cables using generators and receivers similar (but not identical) to those specified by RS-422. Using the 150 sets of measurements recorded from the tests, the following equation was derived through a multiple variable regression analysis with an index of determination of 0.998:

$$DRT = \frac{(K)\ D^{.46}}{R^{2.3}\ L^{2}} \times 10^{6}\ \text{kbit/s}$$

where:

DRT = Data Rate Threshold (Maximum) in kbit/s
K = 4.27 (4.92 when using English measurement)
D = peak distortion (jitter) in percent
R = loop resistance per kilometer (per mile)
L = length of cable in kilometers (miles)

Typical unloaded twisted-pair telephone cable of various gauges having a shunt capacitance of 0.37 to 0.62 microfarads per kilometer between the wires of the pair were used. This equation can apply to data signalling rates up to 100 kbit/s which was the limit used in the tests. At higher frequencies, twisted-pair cable generally displays different characteristics.

An example of operating distances that can be realized for a selection of standard data signalling rates over different gauges of twisted-pair cable is shown in Table 2. These were calculated using the above equation with a peak distortion value of 25 percent which assures a reasonable margin for most center sampling applications. Although the equation can be a useful guide in estimating performance that may be expected in a particular application, it should be realized there may be additional influencing factors in the specific operating environment that must be taken into account.

TABLE 2

Maximum Cable Lengths for Various Standard Data Signalling Rates and Wire Gauges

Data Signalling Rate	Distance in kilometers (miles)			
kbit/s	26 AWG	24 AWG	22 AWG	19 AWG
56	0.8 (0.5)	1.4 (0.9)	2.4 (1.5)	5.4 (3.4)
9.6	2.0 (1.2)	3.4 (2.1)	5.8 (3.6)	13.1 (8.2)
4.8	2.8 (1.7)	4.8 (3.0)	8.3 (5.2)	18.5 (11.6)
2.4	4.0 (2.5)	6.8 (4.2)	11.7 (7.3)	26.2 (16.4)
1.2	5.6 (3.5)	9.6 (6.0)	16.6 (10.3)	37.1 (23.1)

NOTES:

1. Typical unloaded twisted-pair copper telephone cable
2. Shunt capacitance between 0.37 and 0.62 µf/km (0.6 and 1.0 µf/mile)
3. Maximum peak distortion (jitter) 25%

The greatly improved performance now available from the balanced electrical characteristics opens the way for a number of applications where data terminal equipment (DTE) can be directly connected via unloaded twisted pair cable to a central computer, concentrator or other DTE's within a large commercial or government facility. As a result, the requirement and expense for data circuit-terminating equipment (DCE), such as modems or data sets, for such "in house" applications is eliminated.

The balanced electrical characteristics can meet a wide range of user applications. As a separate stand-alone standard, FED-STD-1020 (RS-422) can be referenced for application by specific interface standards, as discussed later, as well as specified for any special purpose user application.

2. Unbalanced FED-STD-1030 (EIA RS-423)

The unbalanced electrical characteristics of RS-423 are designed to provide superior performance to those of RS-232C. A low impedance single-ended generator is specified with a differential receiver having a transition threshold of 200mV. Operation over cable distances up to 1200 meters (4000 feet) at data signalling rates up to 3 kbit/s provides good quality signals while keeping near-end crosstalk within 1 volt peak. Likewise, higher data signalling rates up to 300 kbit/s can also be employed for cable distances progressively decreasing to 12 meters (40 feet). The primary limitation of operating distance with unbalanced circuits is near-end crosstalk, rather than signal quality as with the balanced circuits. In comparison, the performance of RS-232C is generally limited to cable distances of 15 meters (50 feet) at data signalling rates up to 20 kbit/s.

The most significant feature built into RS-423 is its capability to interoperate with both RS-232C circuits and RS-422 circuits. This provides the key mechanism for an orderly transition from RS-232C to the new generation of interface standards.

The provisions necessary to ensure interoperation between RS-232C generators and receivers on one side of an interface with RS-423 receivers and generators on the other side are given in the EIA Electronic Industries Bulletin, Application Note on Interconnection between Interface Circuits Using RS-XYZ/RS-423 and RS-232C. The onus for interoperation rests with the equipment implementing RS-423 so no retrofitting will be required for existing RS-232C equipment. The EIA application note specifies that attention must be given to generator risetime and receiver tolerance of higher RS-232C voltages. A further description of the adaptation of a new generation interface to RS-232C is discussed in Section 5. When interoperating with RS-232C equipment, it must be remembered that the performance is limited to that associated with RS-232C.

The receiver specification of RS-423 is identical to that specified for RS-422. The only difference in application lies in the configuration of the input leads to the differential receiver. The unbalanced configuration ties the B' lead to a signal common return while the balanced configuration uses a separate cable pair between each generator and receiver. Figure 3 shows alternatives of how RS-423 equipment on one side of an interface can connect with RS-422 equipment on the other side of the interface. In effect, circuits from left to right operate unbalanced, while circuits right to left operate balanced. A summary of the considerations for interoperation between RS-422 and RS-423 circuits is as follows:

a. The interconnecting cable lengths are limited by performance of the circuits working to the RS-423 side of the interface.

b. The B' input leads to the receivers in the equipment using RS-423 must be configured to allow connection to RS-422 generators.

c. The optional cable termination resistance (R_t), if implemented, in the equipment using RS-422 must be removed.

d. The B' input leads to the receivers in the equipment using RS-422 must be configured with a common return for operation with RS-423 generators as in Configuration A or connected to signal ground in the RS-423 equipment as in Configuration B.

The unbalanced electrical characteristics provide the essential path which will allow a user to gracefully phase existing equipment out of use while bringing in the new generation of equipment to meet his advancing requirements. At the same time, a significant improvement in operating performance can be realized as the RS-232 equipment phases out. As a separate stand-alone standard, FED-STD-1030 (RS-423) can be referenced for application by specific interface standards, as discussed later, as well as specified for any special purpose user application.

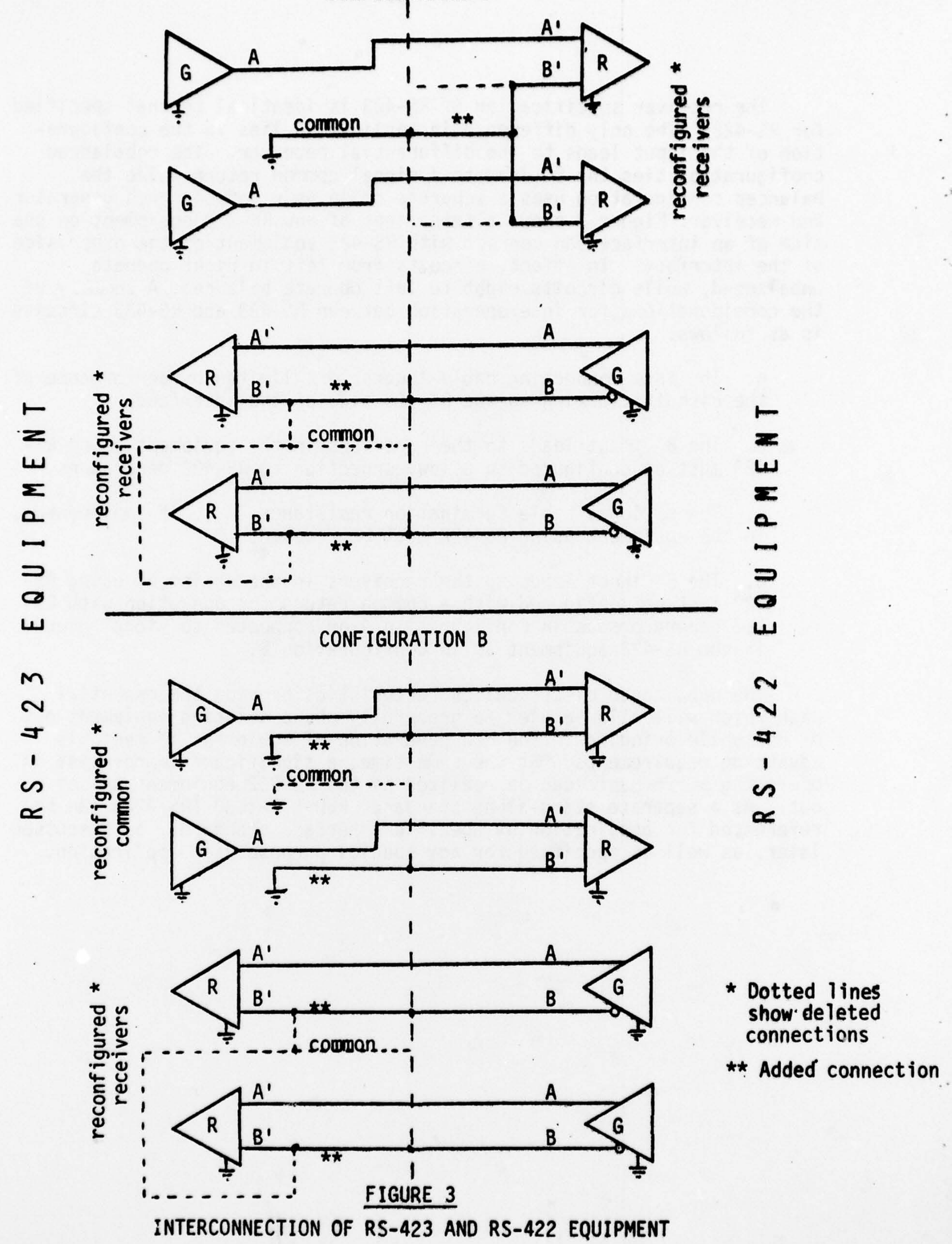

FIGURE 3

INTERCONNECTION OF RS-423 AND RS-422 EQUIPMENT

V
SPECIFIC STANDARD LEVEL 1 INTERFACES

The new generation of Level 1 interface standards covers a much wider range of applications. These include the common DTE-DCE interface for data transmission over analog telecommunication networks using modems (or data sets) and the DTE-DCE interface for the newly emerging public data networks providing circuit switched, packet switched, and leased circuit services. Provision for direct DTE-DTE operation is also being addressed together with transitional and other features to allow design of new DTEs with the flexibility that is essential to meet the spectrum of users' data communication requirements.

1. Data Transmission through Analog Telecommunication Networks

The DTE-DCE interface for applications involving modems has traditionally required the use of a number of parallel control circuits for operation of the modem. These are necessary for such functions as changing direction of transmission in half duplex operation over 2-wire circuits, modem synchronization, and control of fault isolation loop-backs. Table 3 provides a list of the circuits that have been identified for this application. All are not necessarily used by every implementation, but rather an appropriate selection is used for particular operating configurations.

The new generation is planned as a two step evolution from the existing EIA RS-232C. The proposed FED-STD-1031 (EIA RS-XYZ) provides the initial transition mechanism with the objective of evolving to the future use of proposed FED-STD-1029 (EIA RS-ABC). The details of these standards are described as follows:

(a) FED-STD-1031 (EIA RS-XYZ)

As the first step toward the new generation of interfaces, RS-XYZ was developed as a transitionary interface. At the same time, a number of improvements have been made to provide superior performance to RS-232C. RS-XYZ has been primarily designed, as RS-232C, for "nonengineered" user applications which allows equipment of one manufacturer on one side of the interface to be directly connected to equipment of another manufacturer on the other side of the interface without additional technical considerations. "Engineered" applications where attention must be paid to signal waveshaping, cable distance, and mechanical configuration to optimize performance is not precluded by RS-XYZ, but is considered beyond its scope.

One of the more notable improvements of RS-XYZ over RS-232C is the specification of the new unbalanced electrical characteristics of RS-423. Not only does this provide significantly improved performance

CIRCUIT MNEMONIC	CIRCUIT NAME	CIRCUIT DIRECTION	CIRCUIT TYPE	
SG	SIGNAL GROUND	-		
SC	SEND COMMON	TO DCE	COMMON	
RC	RECEIVE COMMON	FROM DCE		
IS	TERMINAL IN SERVICE	TO DCE		
IC	INCOMING CALL	FROM DCE	CONTROL	
TR	TERMINAL READY	TO DCE		
DM	DATA MODE	FROM DCE		
SD*	SEND DATA	TO DCE		PRIMARY CHANNEL
RD*	RECEIVE DATA	FROM DCE	DATA	PRIMARY CHANNEL
TT*	TERMINAL TIMING	TO DCE		PRIMARY CHANNEL
ST*	SEND TIMING	FROM DCE	TIMING	PRIMARY CHANNEL
RT*	RECEIVING TIMING	FROM DCE		PRIMARY CHANNEL
RS*	REQUEST TO SEND	TO DCE		PRIMARY CHANNEL
CS*	CLEAR TO SEND	FROM DCE		PRIMARY CHANNEL
RR*	RECEIVER READY	FROM DCE	CONTROL	PRIMARY CHANNEL
SQ*	SIGNAL QUALITY	FROM DCE		PRIMARY CHANNEL
NS*	NEW SIGNAL	TO DCE		PRIMARY CHANNEL
SR	SIGNALLING RATE	TO DCE		PRIMARY CHANNEL
SSD**	SECONDARY SEND DATA	TO DCE		SECONDARY CHANNEL
SRD**	SECONDARY RECEIVE DATA	FROM DCE	DATA	SECONDARY CHANNEL
SRS**	SECONDARY REQUEST TO SEND	TO DCE		SECONDARY CHANNEL
SCS**	SECONDARY CLEAR TO SEND	FROM DCE	CONTROL	SECONDARY CHANNEL
SRR**	SECONDARY RECEIVER READY	FROM DCE		SECONDARY CHANNEL
LL	LOCAL LOOPBACK	TO DCE		
RL	REMOTE LOOPBACK	TO DCE	CONTROL	
TM	TEST MODE	FROM DCE		
SS	SELECT STANDBY	TO DCE		
SB	STANDBY INDICATOR	FROM DCE	CONTROL	

NOTES:
1. *indicates circuits implementing balanced RS-422 characteristics in RS-ABC. In all other cases the unbalanced RS-423 characteristics are used.
2. **indicate circuits not employed in RS-ABC.

TABLE 3
RS-XYZ/RS-ABC INTERCHANGE CIRCUITS

between RS-XYZ equipment, but facilitates interoperability with RS-232C. The potential performance of RS-423 has not been fully taken advantage of by RS-XYZ because of the requirement for compatibility with RS-232C. It was necessary to select a 5 microsecond risetime for the RS-423 generators to facilitate interoperability with RS-232C equipment for data signalling rates below 10 kbit/s without adjustment to the wave-shaping in the RS-XYZ equipment. This is considered to cover the large majority of RS-232C applications. Due to further near-end crosstalk considerations, the 5 microsecond risetime limits the RS-XYZ equipment to data signalling rates of 60kbit/s and cable distances of 61 meters (200 feet). This is still a significant improvement over RS-232C which is limited to 20kbit/s and 15 meters (50 feet).

Two interchange circuits, AA and CI, little used in RS-232C in the past have been deleted from RS-XYZ while a number of circuits have been added to satisfy new requirements. The new interchange circuits include the following:

IS, Terminal in Service, indicates that a DTE can accept incoming calls. This is particularly useful for the DTE to busy-out a line in a multiline hunting group.

NS, New Signal, is intended for use at the control station of multipoint polling systems where remote DCE's operate in switched carrier mode.

LL, Local Loopback, is used in fault isolation to establish a loop at the line side of the local DCE to check its functioning through the interface, and the transmit and receive sections of the DCE.

RL, Remote Loopback, establishes a loop at the distant end to check the transmission path up to and through the remote DCE.

TM, Test Mode, provides the indication to the DTE that a loop has been established.

SS, Select Standby, allows the DTE to switch the DCE to an alternate channel.

SB, Standby Indicator, indicates when standby channel has been selected.

Another significant change in RS-XYZ is the specification of a 37-pin connector from the same connector family as the 25-pin connector commonly used for RS-232C. The enlarged connector is necessary to accommodate the new interchange circuits as well as the use of the balanced electrical characteristics for future evolution.

A number of key provisions have been included in RS-XYZ which will allow interoperation with equipment meeting RS-232C on the other side of an interface. The onus for adaptation to RS-232C is on the RS-XYZ equipment so no costly retrofits are required to existing equipments. The requirements to be met to ensure proper interoperation are described in the EIA Industrial Electronics Bulletin, Application Note on Interconnection between Interface Circuits Using RS-XYZ/RS-423 and RS-232C. It must be remembered that when interoperating between RS-XYZ and RS-232C equipment, the performance is limited to that associated with RS232C. The improved performance of RS-XYZ is only realized when operating an RS-XYZ DTE with an RS-XYZ DCE.

An example method of implementation utilizing a simple passive adapter between the RS-XYZ and the RS-232C equipment, as shown in Figure 4, is also described in the EIA bulletin. It provides the necessary mechanical, electrical, and functional adaption to ensure proper interoperation. It is expected that such an adapter will cost less than $10 which is considerably less than prematurely obsoleting existing serivceable equipment.

(b) FED-STD-1029 (EIA RS-ABC)

The second step in the evolution is provided by the companion standard RS-ABC. The basic specification for the functional and mechanical characteristics of RS-XYZ for DTE-DCE applications are retained while the balanced electrical characteristics of RS-422 are applied to 10 of the interchange circuits. These circuits are identified by an asterisk in Table 3 and include the data and timing circuits plus the control circuits that may switch at the operating data signalling rate. By utilizing the balanced electrical characteristics, data signalling rates up to 10 Mbit/s as well as greatly increased cable distances become possible as discussed in the earlier section on the electrical characteristics.

As a result of the much wider range of operating characteristics that are possible, the necessity for additional technical considerations outside the scope of the standard to tailor specific applications is greatly reduced. The notion of "nonengineered" and "engineered" applications, previously mentioned under RS-XYZ, virtually disappears. The improved operating performance also makes DTE to DTE operation an economically practical proposition. Accordingly, RS-ABC includes suitable direct connection configurations without intermediate DCE's to meet users' "in-house" applications.

The balanced electrical characteristics do have the disadvantage of requiring two connector pins for each circuit rather than one. It was felt that instead of using a larger connector than specified for RS-XYZ to accommodate the balanced circuits, the interchange circuits specified by RS-XYZ for secondary channels should be eliminated to make the needed pins available. It is expected that there will be little use of secondary channels in the future.

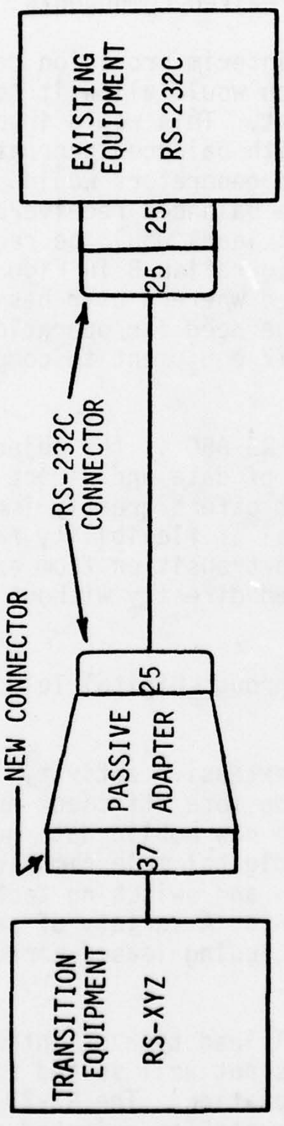

FIGURE 4

ADAPTATION OF RS-XYZ TO RS-232C

A compatible pin numbering plan has been established which will facilitate converting RS-XYZ equipment to meet RS-ABC if necessary considerations have been taken into account in the initial design of the RS-XYZ equipment. Effectively, only the unbalanced generators have to be replaced with balanced generators on the designated circuits while the receiver input leads need to be reconfigured to operate with balanced generators. This conversion could be readily accomplished by either a change in a circuit card or through a switching or strapping arrangement of prewired components.

An additional interim provision can also be incorporated into the RS-XYZ equipment which would allow it to be adapted for interoperation with RS-ABC equipment. This would involve reconfiguration of the receivers for operation with balanced generators as required for the conversion, but the unbalanced generators would remain in the RS-XYZ equipment and operate with the balanced receivers of the RS-ABC equipment. The interchange circuit leads would be reconfigured for the common return similar to configuration B in Figure 3. Adaptation of RS-XYZ to RS-ABC could be employed where a user has both RS-232C and RS-ABC equipment in service. Once the need for operation with RS-232C fades out, final conversion of RS-XYZ equipment to comply with RS-ABC can be accomplished.

Application of RS-ABC is the objective for future interfaces for analog transmission of data and direct DTE to DTE operation without intervening DCE's. It offers greatly improved performance over RS-232C as well as a great deal of flexibility for users' applications. Where a user has no need for a transition from existing RS-232C equipment, RS-ABC may be implemented directly without the intervening RS-XYZ step.

2. Data Transmission through Digital Telecommunication Networks, FED-STD-1040 (ANSI X.21)

There is currently extensive activity in many countries throughout the world to provide more efficient and economical data communication services through new public data networks for the user community. Many of these new digital telecommunication networks will employ the latest transmission and switching technology specifically tailored for data communications. A variety of services will be available in these new networks including leased circuit, circuit switched, and packet switched operation.

The multiple control lead type of interface associated with analog transmission of data is not well suited for the new technology to provide the most efficient operation. The RS-232C/RS-XYZ/RS-ABC interfaces are more hardware implementation oriented rather than software based for the advancing microprocessor technology. Therefore, it is necessary to specify another Level 1 protocol to serve as the general-purpose interface for the new digital telecommunication networks.

FED-STD-1040 (X.21) adopts the American National Standard, referred to as "ANSI X.21," which is based upon the work of ISO and CCITT. This standard has full international acceptance and is applicable for Level 1 to connection of all DTE's to any digital telecommunication network. Operation of Levels 2, 3, and higher for more specific applications such as packet switched service, is dealt with by other standards.

X.21 is a simple interface implementing a minimum number of interchange circuits across the interface to provide full transparency (bit sequence independence) for the transfer of data. Figure 5 illustrates the interface together with the designation of the associated interchange circuits. The transmit (T) and receive (R) circuits are used for conveying both control information and data, depending upon the operating phase. The control (C) circuit serves the basic ON/OFF hook function to start the Call Establishment Phase or the Clearing Phase. The C circuit is the key to maintenance of transparency by preventing data from "talking" a circuit into disconnection or misoperation with certain bit patterns. The indication (I) circuit in the ON state signifies that the establishment of the link is complete and the Data Transfer Phase can proceed. The user is free to use any format, frame synchronization, and procedure mutually agreed with the other end of an established connection by employing the higher level protocols during the Data Transfer Phase as previously discussed in Section III of this TIB.

The Level 1 procedures of X.21 cover a variety of services to establish a connection. They include addressed (dial-up), direct (hot line) connection, and demand leased circuit service through a circuit switched network as well as point-to-point leased circuit service. Also, a standard 15 pin connector is specified from the same connector family as the 25 and 37 pin connectors used for the RS-232C and RS-XYZ/RS-ABC interfaces respectively.

The electrical characteristics of RS-422 are specified for the DCE while the DTE may implement either RS-422 or RS-423. This enables DTE's designed for a number of applications to also meet X.21 without having to change the electrical characteristics. For example, a DTE could be designed to meet both RS-XYZ and X.21 using RS-423 unbalanced electrical characteristics or meet both RS-ABC and X.21 using RS-422 balanced electrical characteristics.

There is also sufficient functional similiarity between X.21 and RS-ABC/RS-XYZ to facilitate the design of a multipurpose DTE. The adaptation of the EIA interface circuits with the respective X.21 circuits is shown in Figure 6. A further provision for mechanical 37 to 15 pin adaptation is also required, but is considered a simple inexpensive matter.

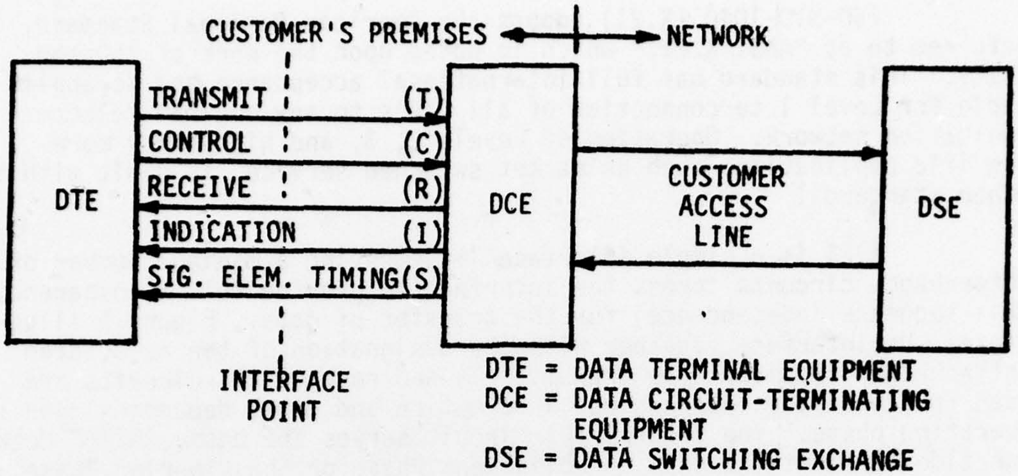

FIGURE 5

X.21 INTERFACE

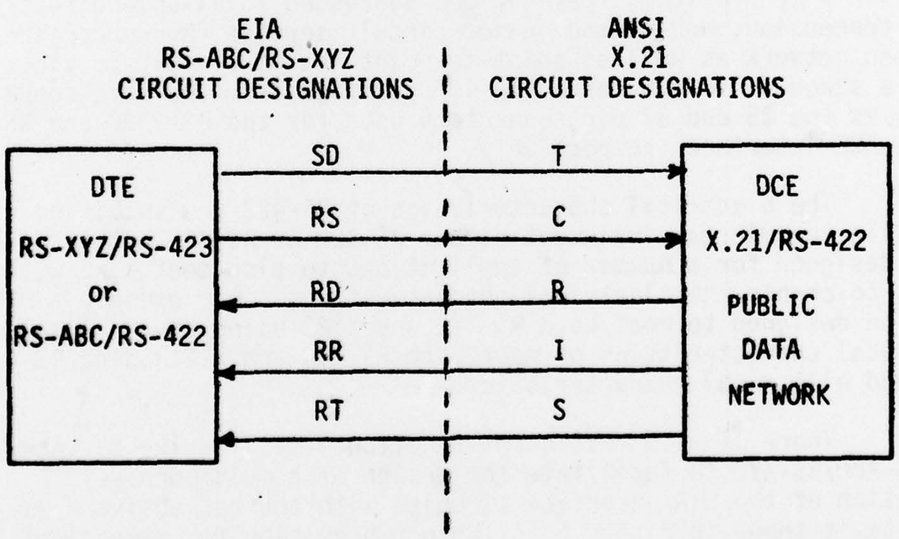

FIGURE 6

ADAPTATION OF EIA INTERFACES TO PUBLIC DATA NETWORKS

A multipurpose DTE which meets both X.21 and RS-ABC or RS-XYZ, must of course be able to operate with the different Level 1 procedures associated with each standard. With today's microprocessor technology, this now becomes an economically realizable proposition.

X.21 provides the final part of the new generation of data communication interfaces. Together with its companion RS-ABC for analog applications, the spectrum of users' needs are well covered at the first level of the interface protocol hierarchy.

VI
THE TRANSITION

The new generation of data communication interface standards offer greatly improved operating performance over the existing RS-232C and cover a wider range of user applications. The most important factor, however, is the provision that has been carefully incorporated to facilitate an orderly transition without forcing obsolscence or costly retrofits.

There are a number of ways that a user may proceed in the evolution to the new generation of data communication equipment. If there is an inventory of RS-232C equipment which still has a useful life, implementation of RS-XYZ with the provisions for interoperation with RS-232C equipment would be in order. If applications using new public data networks or private digital telecommunication networks are foreseen, the user may wish to implement a multipurpose RS-XYZ DTE which is adaptable to the X.21 interface.

RS-ABC provides the greatly improved specification for the new generation of applications for analog telecommunication networks as well as direct DTE to DTE operation without intervening modems. If interoperation with existing RS-232C equipment is not important to a user, RS-ABC can be implemented directly. On the other hand where RS-XYZ is necessary for an economical transition, the provision for adaptation and then subsequent conversion to RS-ABC can be readily accommodated.

An illustration of the relationships between the various interface standards is shown in Figure 7. The new RS-XYZ equipment, through adaptation, can interoperate with existing RS-232C equipment which, therefore, can be retained by the user. Additional flexibility is also possible for the RS-XYZ equipment to adapt for operation with RS-ABC equipment during the transition. Furthermore, the RS-XYZ equipment may be designed to adapt to X.21 for operation through the new digital networks. Finally, RS-XYZ can be converted to RS-ABC to become the new generation interface for data transmission through analog telecommunication networks as well as for direct DTE to DTE operation. As with RS-XYZ DTE's, RS-ABC DTE's can also be designed to adapt to X.21 for operation through the new digital public data networks. The user now has the flexibility to determine whether he requires a multipurpose DTE meeting both RS-ABC and X.21 to serve the spectrum of applications or whether he only needs to meet a narrower range of applications by implementing just one of the standards.

It is not a proliferation of interface standards that is being developed for the next generation of data communication equipment, but a carefully planned evolution into the future is being provided. A user

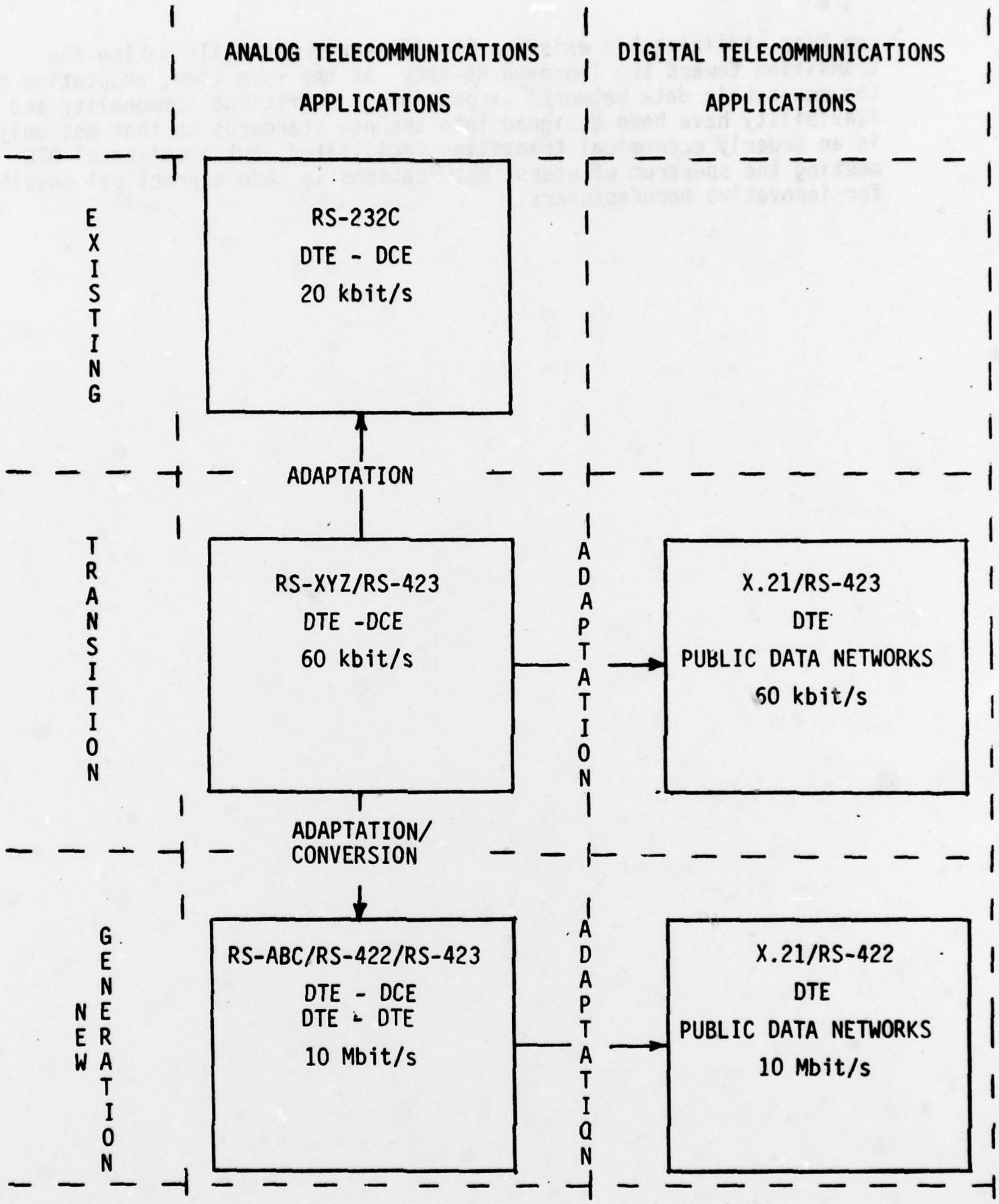

FIGURE 7

INTERRELATIONSHIPS OF INTERFACE STANDARDS

can keep utilizing his existing RS-232C equipment while making the transition toward the improved RS-ABC. At the same time, adaptation to the new public data networks is possible. Sufficient commonality and flexibility have been designed into the new standards so that not only is an orderly economical transition facilitated, but a universal DTE meeting the spectrum of users' applications is made a practical possibility for innovative manufacturers.